Diaphragm Abutments

The monolithic diaphragm abutment, an integral part of the bridge superstructure extending below the soffit, is connected directly to piles or rests on a footing cap. The roadway embankment is in direct contact with the abutment diaphragm. The major benefits of the diaphragm abutment are its low initial cost, its effectiveness in absorbing seismic loads and its ability to accommodate structurally, relatively large thermal movements. Reinforced concrete bridges up to 400 feet in length have shown no evidence of structural distress of the abutment from thermal movements.

The two main disadvantages of the diaphragm abutment are (1), continuous maintenance of the approach embankments due to settlement at the paving notch and along the wingwalls and (2), damage to the approach embankment and pavement caused by water intrusion between the abutment diaphragm and approach roadway.

With water intrusion being the main problem for diaphragm abutments, the current structure approach has been designed to prevent water from entering behind the abutment and along the wingwalls. The structure approach is connected directly to the abutment and extends over the wingwalls. An underlying drainage system provides additional insurance against erosion.

See Memo to Designers 5-1 for design criteria of a diaphragm abutment.

Uses and Limitations

1. Diaphragm abutments shall not be used for new construction when the abutment joint movement exceeds 1/2" and the new structure approach is not used. When the new structure approach is used, the movement shall not exceed 1" at the expansion joint between the approach slab and sleeper slab. The movement calculation shall include temperature, creep and long-term prestress shortening in accordance with Memo to Designers 7-10, "Bridge Expansion Joints and Deck Joint Seals".

2. Diaphragm abutments shall not be used where the roadway surface of overcrossings is designed to carry storm water by open channel flow across the freeway, usually in a freeway cut situation (see Memo to Designers 18-4).

3. For cast-in-place prestressed concrete bridges, the Standard 16" CIDH pile has not been designed for connecting the pile directly to a diaphragm abutment. Connecting a CIDH pile directly to the abutment requires a special design of the CIDH pile plus additional prestress force in the superstructure to account for the CIDH pile stiffness. When the Standard CIDH piles are used, the superstructure should be free to shorten as shown in *Bridge Design Aids* 1-4 (Diaphragm Abutment with Footing).

Supersedes Memo to Designers 5-2 dated December 1988

Skewed Abutments

The lateral earth pressure on a skewed abutment produces a resultant horizontal force that is eccentric to the center of resistance of the substructure element. This horizontal force must be resisted at the abutment or taken into account in the design of the bents.

For bridges with hinges in the superstructure, regardless of skew, the abutment or the bents must resist the lateral earth pressure behind the abutment.

The seat cantilever abutment should be considered, rather than the diaphragm abutment, to resist lateral earth pressures of skewed abutments, structures with hinges and also as a method to reduce the number of hinges required by changing the point of no movement in the superstructure.

Drainage

The primary objectives of the drainage system behind the diaphragm abutment are to reduce hydrostatic pressure and to control the erosion of the embankment.

Section 610.4(3), "Structure Approach Drainage", of the *Highway Design Manual* outlines the drainage requ[illegible] ils are shown on the respective structure approach standard detail sheets.

Standard Plan B0-3, "Bridge Detail 3-5, 8" PSP and Permeable Material" is specified when known water bearing material is present behind the abutment, regardless of structure approach drainage.

Standard Plan B0-3, "Bridge Detail 3-1, Weep Hole and Previous Backfill" is specified when the other drainage systems are not used. The substitution of geocomposite drain for Bridge Detail 3-1 should be shown on the plans behind abutments and retaining walls as shown in *Bridge Design Details* pg. 6-22, "Weep Hole and Geocomposite Drain".

Jerry A. McKee

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Floyd L. Mellon

Floyd L. Mellon

TPJ:dm

5-2 DIAPHRAGM ABUTMENTS

The monolithic diaphragm abutment, an integral part of the bridge superstructure extending below the soffit, is connected directly to piles or rests on a footing cap. The roadway embankment is in direct contact with the abutment diaphragm. The major benefits of the diaphragm abutment are its low initial cost, its effectiveness in absorbing seismic loads and its ability to accommodate structurally, relatively large thermal movements. Reinforced concrete bridges up to 120 meters in length have shown no evidence of structural distress of the abutment from thermal movements.

The two main disadvantages of the diaphragm abutment are (1), continuous maintenance of the approach embankments due to settlement at the paving notch and along the wingwalls and (2), damage to the approach embankment and pavement caused by water intrusion between the abutment diaphragm and approach roadway.

With water intrusion being the main problem for diaphragm abutments, the current structure approach has been designed to prevent water from entering behind the abutment and along the wingwalls. The structure approach is connected directly to the abutment and extends over the wingwalls. An underlying drainage system provides additional insurance against erosion.

See Memo to Designers 5-1 for design criteria of a diaphragm abutment.

Uses and Limitations

1. Diaphragm abutments shall not be used for new construction when the abutment joint movement exceeds 13 mm and the new structure approach is not used. When the new structure approach is used, the movement shall not exceed 25 mm at the expansion joint between the approach slab and sleeper slab. The movement calculation shall include temperature, creep and long-term prestress shortening in accordance with Memo to Designers 7-10, "Bridge Expansion Joints and Deck Joint Seals".
2. Diaphragm abutments shall not be used where the roadway surface of overcrossings is designed to carry storm water by open channel flow across the freeway, usually in a freeway cut situation (see Memo to Designers 18-4).
3. For cast-in-place prestressed concrete bridges, the standard 400 mm CIDH pile has not been designed for connecting the pile directly to a diaphragm abutment. Connecting a CIDH pile directly to the abutment requires a special design of the CIDH pile plus additional prestress force in the superstructure to account for the CIDH pile stiffness. When the standard CIDH piles are used, the superstructure should be free to shorten as shown in *Bridge Design Aids* 1-4 (Diaphragm Abutment with Footing).

Memo converted to metric.

Skewed Abutments

The lateral earth pressure on a skewed abutment produces a resultant horizontal force that is eccentric to the center of resistance of the substructure element. This horizontal force must be resisted at the abutment or taken into account in the design of the bents.

For bridges with hinges in the superstructure, regardless of skew, the abutment or the bents must resist the lateral earth pressure behind the abutment.

The seat cantilever abutment should be considered, rather than the diaphragm abutment, to resist lateral earth pressures of skewed abutments, structures with hinges and also as a method to reduce the number of hinges required by changing the point of no movement in the superstructure.

Drainage

The primary objectives of the drainage system behind the diaphragm abutment are to reduce hydrostatic pressure and to control the erosion of the embankment.

Section 610.4(3), "Structure Approach Drainage", of the *Highway Design Manual* outlines the drainage requirements associated with the new structure approach. The drainage details are shown on the respective structure approach standard detail sheets.

Standard Plan B0-3, "Bridge Detail 3-5, 200 mm PSP and Permeable Material" is specified when known water bearing material is present behind the abutment, regardless of structure approach drainage.

Standard Plan B0-3, "Bridge Detail 3-1, Weep Hole and Previous Backfill" is specified when the other drainage systems are not used. The substitution of geocomposite drain for Bridge Detail 3-1 should be shown on the plans behind abutments and retaining walls as shown in *Bridge Design Details*, page 6-22, "Weep Hole and Geocomposite Drain".

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